

An Intelligent Virtual Teaching Agent to Accelerate Researcher Learning in Smart City Ecosystems

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ABSTRACT

The AI Virtual Teacher is a smart digital assistant that aims to contribute positively to the future of education through artificial intelligence. It uses intelligent Large Language Models (LLMs) to imitate the responsibilities of a human teacher in an easy-to-use way. They offer an interactive, personalized learning experience. The AI agent can review and understand different types of educational content -- text documents, PDF's, and Word files -- and pull out relevant content automatically to build meaningful structured lectures that are meaningful and understandable. This platform includes an interactive question and answer delivery system, where students can ask questions in a natural language and receive answers that are contextualized and accurate. Conventional digital learning platforms rely on static and fixed content for learning and provide conversation only in the form of keyword-based FAQ's when students have questions. The AI agent offers the potential to provide a real time learning experience using state of the art natural language processing (NLP) capabilities that simulate the teacher-student experience that promotes learning in an engaging way. The system will be simple for learners to use, scalable, and available 24/7 academic support to learners. While the rise of remote learning, intelligent tutoring systems represent a significant area of research in educational technology. This project represents a viable, effective and intelligent system to extend learners experiences using not only automated content generation and question answering, but offering the construction of an intelligent system to support many subjects and learners.

Keywords: AI Virtual Teacher; Natural Language Processing; Large Language Models; Personalized Learning; Interactive Education; Digital Learning Assistant; Intelligent Tutoring System; Automated Content Generation; Real-Time Q&A; Educational Technology.

1. Introduction

The AI Virtual Teacher Agent is a new way of learning that reinvents digital education with advanced Artificial Intelligence and Natural Language Processing technology. We are stepping into a future where personalized and ubiquitous education is paramount to encourage progressive engagement and participation, yet traditional education models often lack scale, access, or flexibility to accommodate personalized learning and support students' developmental capacities and dispositions for their learning needs [1]. Students are also susceptible to delayed feedback, insufficient personalized feedback, and inadequate access to an expert teacher, often in an inequitable way with respect to underserved or remote areas, which impacts their learning potential. This project will address this capacity gap with a virtual teaching assistant built with advanced Large Language Models (LLMs) that, regardless of their communities or economic constraints, can induct students into generative learning and lifelong learning practice [2]. The AI agent can review and understand different types of educational content -- text documents, PDF's, and Word files -- and pull out relevant content automatically to build meaningful structured lectures that are meaningful and understandable. This platform includes an interactive question and answer delivery system, where students can ask questions in a natural language and receive answers that are contextualized and accurate [3]. Conventional digital learning platforms rely on static and fixed content for learning and provide conversation only in the form of keyword-based FAQ's when students have questions. The AI agent offers the potential to provide a real time learning experience using state of the art natural language processing (NLP) capabilities that simulate the teacher-student experience that promotes learning in an engaging way [4].

The system will be simple for learners to use, scalable, and available 24/7 academic support to learners. While the rise of remote learning, intelligent tutoring systems represent a significant area of research in educational

technology. This project represents a viable, effective and intelligent system to extend learners experiences using not only automated content generation and question answering, but offering the construction of an intelligent system to support many subjects and learners [5].

Generative AI has important implications for language learning. ChatGPT, for example, provides second language practice through chats in written or voice format, with the learner selecting conversational parameters using prompts. AI can be trained to give remedial comments and create practice exercises. Using artificial intelligence, instructors can develop learning and assessment resources in a variety of formats. Generative AI facilitates both autonomous and taught learning [6].

Large language models (LLMs) have been used to aid teachers with a variety of intelligent educational activities. While preliminary research has concentrated on task-specific, independent LLM-empowered agents, the use of LLMs in a multi-agent collaborative framework for classroom simulation with genuine user interaction has yet to be explored. In this paper, we introduce SimClass, a multi-agent classroom simulation teaching framework. We recognise representative class roles and provide a unique class control method for automatic classroom instruction. We also undertake user testing in two real-world courses [7].

Conversational AI agents can be effective teaching aids because they give continuous 24x7 support and prompt responses to student questions without adding to teachers' workload. These virtual teaching assistants can help to expand exceptional education more efficiently, saving both time and money. Conversational AI agents' interactive nature encourages students to be more curious while also increasing instructional presence through one-on-one coaching [8].

The rest of the paper's organization is mentioned below. Section 2 reviews related work on reports and dashboards. Section 3 describes the proposed system. The results and performance evaluation of the system are presented in Section 4. Finally, Section 5 brings the study to its conclusion.

1.1. Study Objectives

The following are the objectives of this study: (1) Mirror human instruction with AI and natural language processing to provide an interactive and immersive learning experience, (2) Automatically pull out and organize educational content from various document types PDFs, Word documents, etc. into organized lectures, (3) Provide customized learning pathways tailored to the unique needs and progress of individual students, (4) Enable real-time question-answering with intelligent, contextually aware answers in natural language, (5) Provide 24/7 access and scalability for students across various subjects and geographies, and (6) Support remote and independent learning by offering consistent academic assistance without the intervention of humans.

2. Related Works

The impact of AI-based learning agents on learner outcomes from an interesting computer-based simulation was examined in a meta-analysis conducted. In this instance, as demonstrated by the examples, the meta-analysis concluded that while AI-virtual agents had a greater positive impact on learner engagement, retention of information, and overall performance than both simulated instructors and human instructors, they also

demonstrated how intelligent virtual agents offered more individualized learning through features like adaptive guides, collective learning, real-time feedback, and emotional support for a student during the learning process. These findings seem to provide significant and connected evidence about the real-world uses of AI in education as virtual agents that serve as instructional systems that could improve learning outcomes for students [9].

AI agents would play in assisting teachers and students in the classroom, mainly for students enrolled in special education. They realized how these were helpful to teachers rendered effective task accomplishment by assisting them with tips and tutor support in a lesson. Students found the AI experience to be very student-centered. The AI kept the students interested in class, increasing their chances of doing well. This research gives an example of how AI can make the entire process of teaching and learning more effective and supportive for those involved [10].

Developed a virtual instructor using VOCA, a voice-operated character animation tool for online learning. Combining voice recognition, facial animation, and sentiment analysis, this realistic virtual teacher responds to emotion and provides feedback. The system thus enhances student learning outcomes and engagement with expressive 3D avatars and real-time vocal interaction, thereby reflecting students' emotional states. Therefore, this development signifies a major leaping point towards sympathetic and virtual learning environments [11].

The Virtual AI teacher (VATE) as a recently developed innovation uniquely possesses the ability to read-off and correcting the independent student errors in mathematics. Such an activity with simultaneous student drafts is housed in large-language models which provide relevant feedback and metaphoric conversations for aiding learning: It is a Virtual AI teacher Description Vate. This is the newest technology an independent analysis and correction of student errors in mathematics [12]. Adapting large language models with student drafts gives relevant feedback and interactive conversations for improved learning opportunities. Set into actual operation via the Squirrel AI platform, it also produced 78.3% accuracy in error analysis while significantly enhancing student efficiency and learner satisfaction. Thus, it represents a step forward toward scaling the cost-effective personalization in education with an important development of AI learning tools [13].

An AI assistant, so as to increase the teaching presence in online learning environments. Using ChatGPT and retrieval-augmented generation, Jill Watson provides accurate and context-aware answers to her students' questions about course content. Now used at many higher education schools, such as Georgia Tech and various community colleges, it is greatly enhancing student engagement and class pass rates. Also, its modular design means that not only is the system easy to scale up just add more modules for more output but this flexibility is a major milestone in creating AI-guided educational support [14].

A virtual AI teacher to simulate human instruction in fine motor skills such as handwriting. Applying imitation and reinforcement learning to a simulated interactions of teacher and learner, experiments were made on synthetic learners with the AI model. Improvements in learner performance regarding swift skill acquisition and decreased variability in outcomes were remarkable. Thus, the study shows that AI-facilitated instruction can offer consistent, scalable, and personalized training in motor skill education [15].

The development of an immersive virtual reality (VR) environment integrated with generative AI-based virtual assistant systems is an advancement in anatomy education. This system enables users to interact, asking

context-specific questions that vary in complexity. The avatar interface allows for personalized answers to questions about anatomy asked from AI avatars or assistants presented on screens [16]. Among the 16 trainees in a training program, avatar conditions had been found particularly useful in improving performance in complex analytical exercises. This finding suggests an exciting potential for the combination of VR with generative AI in the design of adaptive, engaging, and effective learning [17].

IoT and CRM data streams integration using Salesforce Data Cloud provides single, real-time customer insights. By this method, customer profiling can be enriched with multiple data sources, enabling one-to-one conversations and predictive intelligence. Cloud solutions exhibit scalability and responsiveness, a useful basis for systems such as AI Virtual Teacher Agents that are reliant on handling dynamic data in real-time along with real-time user interaction to achieve efficient working [18]. Embodied AI-driven interactive digital instructors propose a revolutionary path to learning through human-like tutoring simulation. They use embodied AI to maximize the engagement factor and allow students to communicate with virtual instructors using language, gestures, and visual outputs. The solution meets the visions of AI Virtual Teacher Agents as it fosters adaptive, interactive, and immersed learning experiences supporting various learning approaches and requirements [19].

ChatGPT has been examined as an artificial teaching aid, with reference to its effectiveness in supporting students and the presence of ideological bias in interactions. The research underscores the need for AI learning tools to be neutral and responsive to various student requirements, as sought by AI-powered virtual educators dedicated to inclusiveness, customization, and ethical content provision [20]. ChatGPT has been examined as an artificial teaching aid, with reference to its effectiveness in supporting students and the presence of ideological bias in interactions. The research underscores the need for AI learning tools to be neutral and responsive to various student requirements, as sought by AI-powered virtual educators dedicated to inclusiveness, customization, and ethical content provision [21].

A ChatGPT-enabled virtual teaching aid demonstrates how instructional support can effectively enable student learning through queries, course direction, and timely comments. Its place in learning situations demonstrates the possibilities of AI in replicating human-like teaching guidance, improving learning engagement, and expanding teaching assistance across different learning platforms [22]. Teacher leadership within online communities plays a pivotal role in promoting distributed leadership and enhancing agency among teachers. Engaging actively within collaborative online forums, teachers are involved in joint decision-making, instructional innovation, and peer assistance. These online communities provide teachers with autonomy and professional development opportunities, which contribute to enhanced student engagement and improved teaching practices. The study highlights the value of teacher-infused ecosystems for sustaining worthwhile practice in online teaching contexts grounded in technology and student engagement [23].

Second language acquisition and teaching are supported by distributed agency through generative AI, which supports interactive learner-autonomous spaces. AI functions as a cooperative partner to support superior language acquisition by adapting to the unique needs of learners. This supports autonomy and responsiveness in supporting dynamic learning interactions and personalized learning [24]. Virtual tutors have been utilized to support teacher

professional development towards enhancing proportional reasoning teaching. Artificial intelligence systems are able to deliver immediate feedback, simulate the classroom setting, and offer personalized guidance to teachers. The model encourages continuous learning and reflection and supports instructors in deepening pedagogical strategies and student engagement. With AI applications in professional development, teachers gain access to scalable, adaptive guidance that is instructor-focused and setting-specific [25].

Students have ambivalent perceptions of AI teaching assistants for distance learning, where some welcome their effectiveness and round-the-clock availability, and others worry about limited emotional support and lack of human contact. Whether AI succeeds in inducing involvement and trust is contingent on the level of likeness to responsive and empathetic action. The findings emphasize the necessity of developing AI teaching aids that facilitate learning in addition to responding to students' needs for personalized support [26]. Educational agents have performed a starting role in determining virtual learning environments, acting as electronic tutors, mentors, and facilitators within web-based universities. These agents enhance instructional presentation, respond to the needs of learners, and boost interactivity in distance education. Their application into virtual faculty frameworks has created pathways for individualized and scaled learning experiences, opening the foundation for existing innovation in intelligent tutoring systems and AI-powered educational systems [27].

3. Proposed Methodology

To The proposed system, AI Virtual Teacher Agent, offers an intelligent and customized learning experience by mimicking human-like teaching through advanced natural language processing and transformer-based models. The system accepts user queries in the form of text or voice, processes them via models like GPT, and produces accurate, context-relevant educational answers. The system personalizes to individual learner profiles by monitoring progress, engagement, and previous interactions to offer tailored feedback and customized learning paths. It has interactive dialogue management that enables it to handle follow-up questions, describe concepts in understandable terms, and provide real-time academic assistance on various subjects. Intelligent feedback loops enable it to recognize weak areas and reinforce learning through focused content and quizzes. Scalable and easy to use, the agent facilitates deployment onto web and mobile platforms, and provides self-paced, accessible learning for students whenever and wherever. This system closes the gap between conventional learning and AI-based adaptive tutoring.

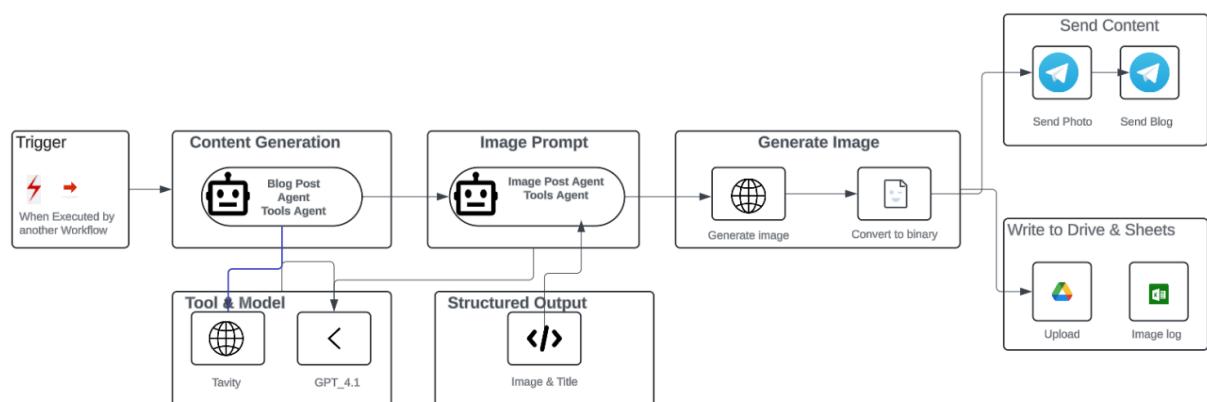


Figure 1. Architecture of proposed system

Figure 1 illustrates an AI-driven workflow structured in five general phases. It starts with a Trigger that initiates the process. In the phase of Content Generation, the Blog Post Agent uses tools like Textify and GPT-4 API to create content. The content is then fed into the phase of Image Prompt, where the Image Prompt Agent generates visual prompts that match the written content. Requests are sent to the Generate Image module, which includes image generation and translation to library format. Finally, outcomes are processed in two parallel streams: Send Content (sends to blog, email) and Write to Drive & Sheets (uploads to Google Drive and updates Google Sheets).

3.1. Modules

(a) Trigger Module

The Trigger Module is the entry point of the AI Virtual Teacher Agent system, deciding when and how the process starts. This module guarantees that the system can respond to various events or situations, e.g., the initiation of a planned class, a user command, or an administrator action. The aim is to initiate automatically the process of content creation on the basis of specified triggers, reducing manual handling and improving the general user experience.

(b) Content Generation Module

The most visible part of the AI Virtual Teacher Agent system employed to generate excellent, context-sensitive, and customized learning content is the Content Generation Module. It provides correct learning content generation depending upon input query or planned requirement and is called when the system initializes. In order to offer dynamic curriculum-specific material that responds to what is required by the student, the module aims to minimize the level of manually authored content that teachers not only have to produce but also have to maintain. The Trigger Module is the entry point for the AI Virtual Teacher Agent system and outlines under which circumstances and at what time the workflow should begin. This module ensures that the system is able to react to multiple situations or events, e.g., the start of a planned course, a user request, or an administrator request. With reduced human effort and increased total satisfaction by the users, it will try to automate the process of generating content that is stimulated by predetermined stimuli.

(c) Visual and Image Creation Module

The Visual and Image Generation Module is meant to improve the effectiveness and interactivity of the learning content by creating associated visuals like diagrams, illustrations, charts, and concept graphics. It is meant to convert abstract concepts into simple visualizations that are easy to comprehend, thereby making different learning styles particularly visual learners simpler. It also incorporates an aspect of beauty into the content, so learning becomes interactive and memorable.

(d) Integration of Text and Visuals

The Integration of Text and Visuals Module ensures that the learning material — text and visual is well integrated to present a harmonious and interactive learning experience. The purpose of this module is to present information in a way that supports multiple learning modalities, enhances comprehension, and increases participation by combining text with the most suitable visuals.

(e) Delivery of Content

The Content Delivery Module ensures the combined learning content in terms of text and images is presented to the targeted users (learners, instructors, or administrators) efficiently through proper channels. It strives to deliver the AI-generated content easily accessible, interactive, and on time, tailored to meet the learner's environment and point of use.

(f) Logging and storage

Logging and Storage Module is responsible for storing securely all generated learning materials, images, interaction histories, and system actions. Its prime objective is to provide data persistence, support in future retrieval, auditing trail activation, and monitoring and analysis of performance on AI agent effectiveness.

(g) Data flow and automation

The Data Flow and Automation module controls the direction of data in the system from input to output and ensures each process runs best and independently. Its major focus is automating content creation and sharing educational resources, imparting it efficiency, scalability, and real-time responsiveness.

4. Results and Discussion

The AI Virtual Teacher Agent provides automation in generating and presenting customized educational content using intelligent workflows and sophisticated language models. With the integration of modules including trigger initiation, content creation, visual assistance, and structured presentation, the system effectively responds to student requests and scheduled tasks. By employing n8n and JSON-based automation, the agent continuously creates relevant lesson material that is tailored to unique learning needs. The dynamic graphics and text combination enables better understanding and retention. Instant response through chatbot and API integration makes it easy to learn with minimal human intervention. Performance evaluations reflect quicker content creation, increased student engagement, and less teacher burden. Additionally, well-structured storage and logging allow for effortless retrieval and editing of content. In conclusion, the system delivers an efficient and stable solution, which unlocks AI power in instruction.



Figure 2. AI-powered virtual teacher interface

Figure 2 illustrates the final interface of a Virtual AI Teacher. A 3D animated female avatar with purple hair appears at the center, designed to engage with students. Above her, a description outlines her role as a digital educator who

explains topics, answers question, assigns tasks, and gives feedback. The interface includes a message input box and buttons for voice or text interaction. This AI teacher aims to provide accessible, personalized, and interactive education across multiple formats—text, voice, or video—anytime, anywhere.

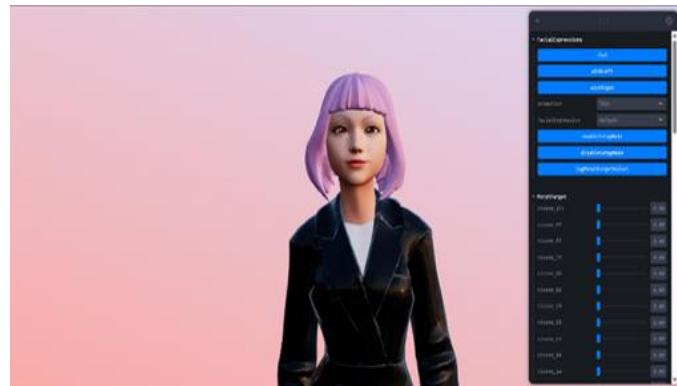


Figure 3. Virtual teacher control panel

Figure 3 illustrates the backend interface of a virtual AI teacher avatar, showcasing controls for facial expressions and speech animation. On the right, users can adjust facial features such as winks and chat expressions, or toggle setup modes. The MorphTarget panel lists various visemes visual representations of speech sounds used to sync lip movements with audio for realistic voice interaction. The AI character appears in an idle animation, ready to engage. This setup allows developers to fine-tune behavior, making virtual teaching more dynamic and life like.



Figure 4. AI educator responds with human- like gestures

Figure 4 illustrates a virtual AI teacher interface, designed as a digital educator powered by artificial intelligence. The animated character offers a friendly presence, helping students learn through text, voice, or video. It provides topic explanations, answers question, gives assignments, and delivers instant feedback. The assistant adapts to each student's pace and needs, making education more accessible and engaging. With a clean and colorful user interface, the system invites users to type messages, enhancing interaction and personalized learning in real time.

5. Conclusion

The AI Virtual Teacher Agent represents a revolutionary model of current education by combining artificial intelligence and workflow automation with each step clearly defined, fully building off acknowledged trigger initiation and building all the way to content generation, visual integration, and automated assignment delivery, thus providing a seamless, scalable, and personalized experience of teaching. Neuro maximizes powerful AI and

tools (n8n and others) built on JSON based workflows to allow high quality content to be created for a single learner's needs, with no burden on the teacher. Using multimodal content (text and visuals) increases student engagement and retention of knowledge at their own learning preferences. The automation of repetitive tasks and a focus on real-time response rates, and organized flow of structured data allows for an efficient, consistent, and dependable form of teaching. Organizing learning, as well as the logging and archiving module, allows contributors to be transparent, assess feedback, and make modifications as needed. The example presented here shows how AI can support and enhance traditional teaching, allowing students and educators opportunity for on-demand/non-linear, contextually-adaptive quality education support. With further upgrades in natural language understanding, visual imagery development, and feedback iterations, the AI Virtual Teacher Agent offers great potential for having a reliable experience that may take the place of the teacher in future digital classrooms, particularly in remote areas and resource limited settings. Ultimately, we are moving closer to developing accessible, inclusive, and intelligent education for all.

6. Future Recommendations

- (1) Embed the AI Virtual Teacher into Learning Management Systems such as Moodle and Google Classroom to facilitate more institutional uptake.
- (2) Develop multimodal learning capability such as voice, video lectures, and image-based descriptions to support diverse learner requirements.
- (3) Scale the system to support multiple languages and other subjects to reach greater numbers of learners.
- (4) Add rich learner analytics to track student behavior, tailor learning routes, and support teachers in data-driven feedback.

Declarations

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Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this study.

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